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(56) Documents cited

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GB 1595432	GB 0556367
GB 1471269	GB 0452520
GB 1374927	

(58) Field of search
E1H
Selected US specifications from IPC sub-class E02D

(54) Pile sections and joints

(57) A pile section for a multi-section pile includes a concrete member (10) having at least one longitudinal steel reinforcing rod (12), the rod including a spigot (14) at one end and a socket (18) at the other which in use are adapted for permanent interconnection so that on driving one section against its neighbour a continuous reinforcing element is provided. This interconnection may be adhered through an epoxy resin filling the clearance between the spigot and socket, or by screw threads. The spigot and/or socket may be of relatively rigid plastics material whereupon the interconnection may be adhered through an interference fit.

The joint may comprise a disc (22) or reticular material which is at least partially collapsible as a result of driving forces applied to the joint and which has a fluent, hardenable filler e.g. epoxy resin in its interstices.

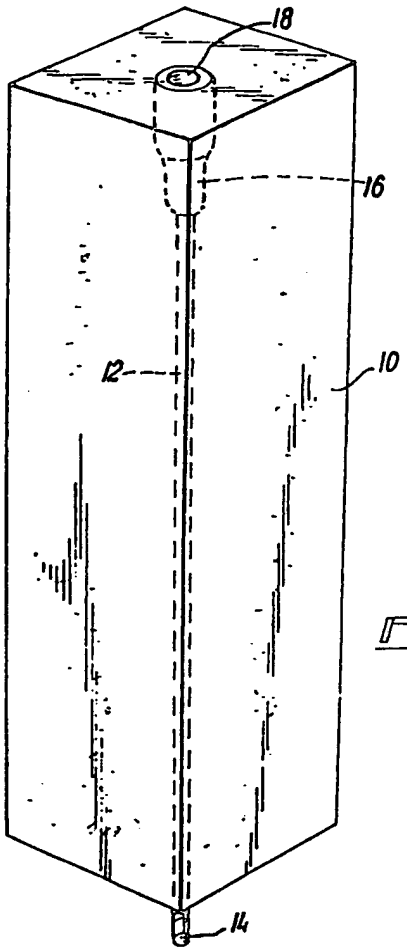

FIG. 1

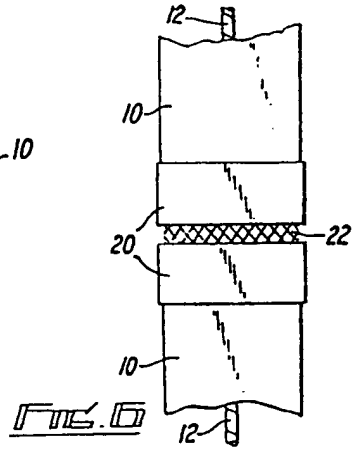

FIG. 6

The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

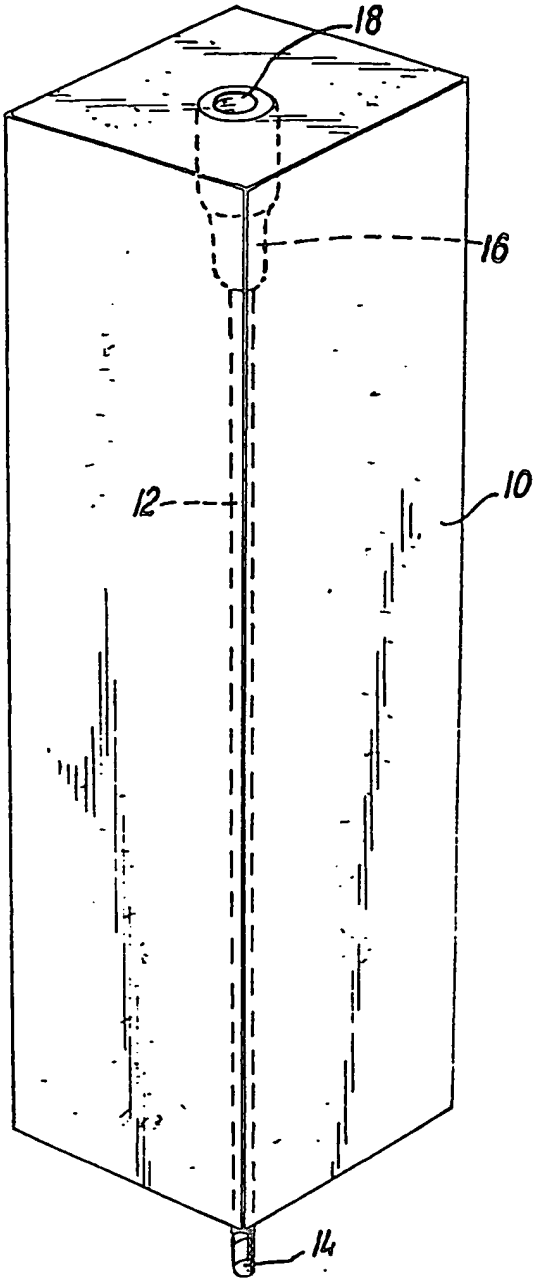

FIG. 1

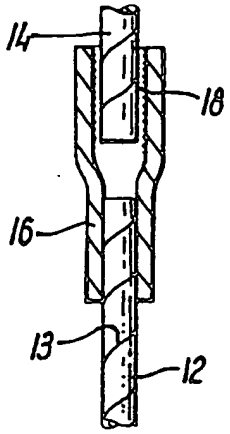

FIG. 2

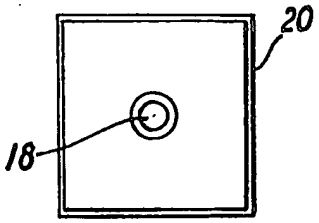

FIG. 5

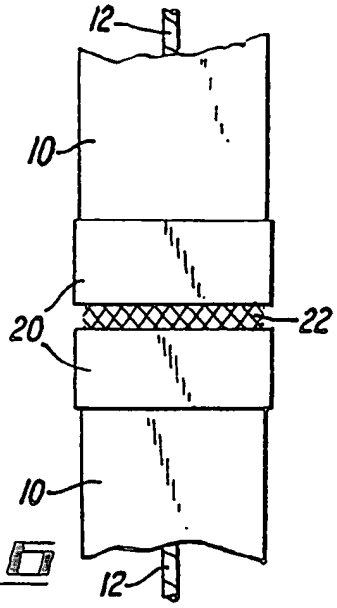

FIG. 6

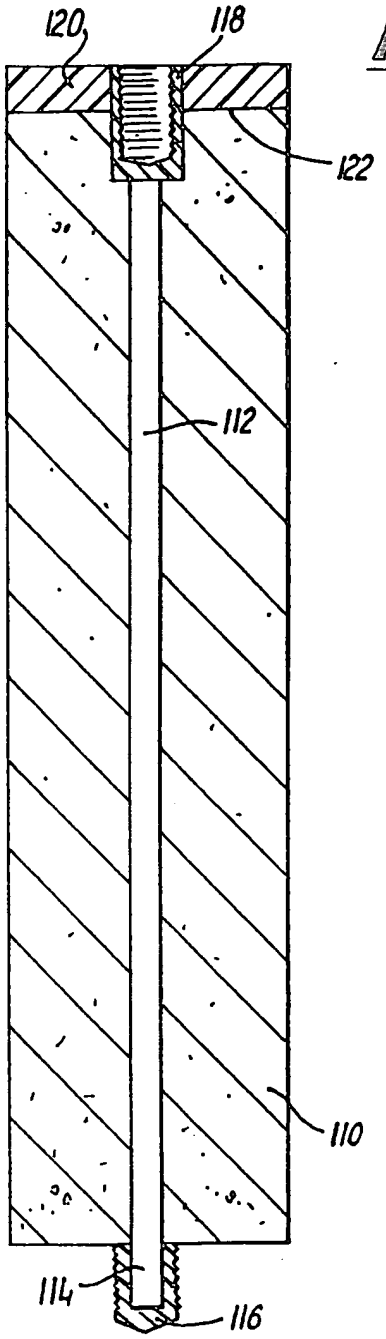

FIG. 3

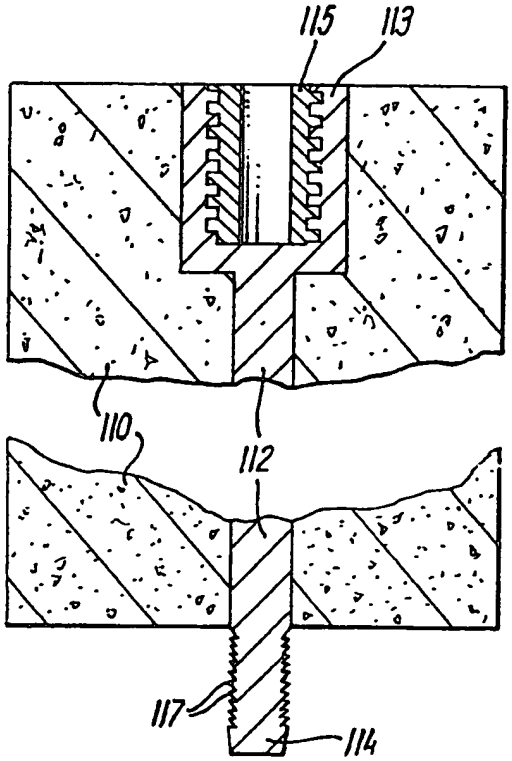

FIG. 4

SPECIFICATION

Improvements in pile sections

The present invention relates to pile sections. Especially but not exclusively, the present invention relates to concrete pile sections adapted to be driven in end-to-end relationship into the ground to form a continuous load-bearing pile.

According to the present invention there is provided a pile section comprising a concrete member including at least one reinforcing means extending generally co-incident with or parallel to the longitudinal axis of the concrete member and provided with interconnecting means at each end adapted to locate and connect with corresponding interconnecting means provided at the ends of a reinforcing means of a similar pile section whereby when similar pile sections arranged in end-to-end relationship the interconnecting means resist movement of one section away from its neighbour.

Preferably the reinforcing means comprises a steel bar or a plurality of substantially parallel steel bars. The interconnection means may comprise a socket fixed to the steel bar at the upper end of the pile section and a spigot formed by or fixed to the end of the reinforcing bar projecting beyond the base of the pile section. Preferably the spigot enters the socket with some clearance and the clearance is taken up by an epoxy resin which, on setting, bonds the spigot to the socket.

Preferably at least one of the facing faces of the spigot and socket are roughened to enhance the adhesion of the epoxy resin.

Preferably the or each reinforcing member is a standard reinforcing bar provided along its entire length with protrusions which may be arranged in a helical formation.

Preferably the spigot is formed at the upper end of the reinforcing bar by a tubular member which forms a spigot and which has its lower end deformed to firmly embrace the upper end of the reinforcing bar such that it is clamped on to the end of the reinforcing bar. Preferably the length of the socket and the deformed end are each so chosen that with a spigot held in the socket by epoxy resin the tensile force required to separate the spigot from the socket and the tubular member forming the socket from the top of the reinforcing bar is greater than the tensile strength of the reinforcing bar.

In a modification the spigot or the socket may be manufactured from a relatively rigid plastics material. In the modification at least one of the spigot and socket preferably have surfaces which provide an interference fit, for example serrated surfaces. The socket is preferably lined by a rigid plastics material lining which is positively located in the socket by, for example, thread means. To co-operate with a lining of this nature the end of the steel bar is serrated, the serrations having a saw-tooth form with the inclined faces of the saw teeth being inclined in the direction of insertion of the spigot into the lining.

In a further alternative interconnecting arrangement a socket may be formed at each end of the bar and a short interconnecting bar having or forming spigots at each end is provided for insertion in adjacent sockets of neighbouring bars to provide the interconnection.

In a still further alternative arrangement the interconnection means may comprise a corresponding externally and internally threaded member. The threads may be multistart threads, may have a large pitch or may have interrupted pitches whereby rigid interconnection of the sections may be achieved with the minimum of rotation therebetween. Any positive interconnection means may be employed but it has to be realised that it must be efficient, long lasting and relatively inexpensive.

According to a further aspect of the present invention there is provided a joint between pile sections including a disc of a reticular material which is at least partially collapsible as a result of force applied to the joint on pile driving and which has in its interstices an epoxy resin.

Preferably the epoxy resin includes also an inert filler. The filler may be sand. The disc may be formed from a metal deformed mesh of the EXPAMET type.

An embodiment of the present invention will now be described by way of example only with reference to the accompanying drawings, in which:-

Figure 1 shows a diagrammatic view of a section of a pile;

Figure 2 shows a cross-sectional elevation of an interconnecting means between two pile sections;

Figure 3 shows a cross-section of a modified pile section;

Figure 4 shows the pile section of Figure 7 on an enlarged scale;

Figure 5 shows a plan view of a top of a pile section; and

Figure 6 shows a joint between two pile sections.

A sectional pile comprises a concrete member 10 of approximately 1 metre in length cast around a central steel reinforcing rod 12 which has integral helical deformations 13 formed thereon. The lower end 14 of the rod projects beyond the base of the pile section 10 to form a spigot and a socket is provided at the other, upper end of the rod 12 by deforming a tube 16 over its lower portion such that it is permanently clamped to the upper end of the bar 12. The deformation leaves the upper end of the tube 16 undeformed with a socket 18 therein, the internal diameter of the socket being greater than the external diameter of the spigot 14 projecting from the base of the next above pile section. The internal surface of the socket is roughened, for example by a screw thread to increase the bonding characteristics.

In operation a pile section is driven into the group and as its top is just about to disappear below ground level a further pile section is placed thereon with the spigot 14 in the socket 18. To ensure a rigid interconnection between the reinforcing bar of adjacent sections to give a continuous reinforcement throughout the multi-section pile an

epoxy resin adhesive is introduced into the socket 18 prior to the introduction of the spigot 14 and when the resin sets a permanent joint between the socket 18 and the spigot 14 is provided.

The epoxy resin has a predetermined adhesive strength and the length of the protrusion of the spigot 14 into the socket 18 is chosen such that the bond between the spigot and socket after the epoxy has set is equal to or greater than the tensile strength of the rod 14. Similarly, the length of the deformed section of the tube 16 clamped around the top end of the bar 12 is chosen such that the strength of the tube/bar joint is greater than or equal to the tensile strength of the bar 12. It will be realised therefore that in a tensile test on a multi-section made-up reinforcement the bar will fail rather than the joint between the spigot and socket or the joint between the tube and the top of the bar.

A modified spigot and socket joint is shown in Figures 3 and 4.

A sectional pile comprises a concrete cylinder 110 of approximately 1 metre in length cast around a central steel reinforcing rod 112. The lower end 114 of the steel reinforcing rod has a high density plastics material cap 116 having a circumferentially ribbed outer profile and a conical lower end moulded thereon. Permanently fixed to the upper end of the reinforcing rod 112, which terminates a distance from the upper end of the pile section, there is provided a high density plastics material hollow cylindrical socket 118, the inner cylindrical surface of which is ribbed to correspond with the ribs on the end cap 116. A relatively incompressible high strength plastics material disc 120 having a central aperture for the end cap 118 may be fitted across the top surface 122 of the pile section.

During a pile driving operation a pointed end piece having an end configuration similar to the top of the pile section described above is fitted to the lower end of a first pile section. The pile section and end piece are then driven into the ground by any suitable pile driving method and after a suitable penetration has been achieved the driving means are removed such that a second similar section can be placed on top of the first section with the cap 116 of the second pile section arranged at the entrance to the cup 118 of the first pile section. Pile driving is recommenced and the first movement of the second pile is a movement relative to the first pile to force the cap 116 into the cup 118 until the lower face of the concrete cylinder 110 of the second section abuts the disc 120 on the top of the first section. A positive interference fit is obtained between the cup 118 and cap 116 thereby effectively extending the length and action of the reinforcing rod 112 through the pair of end-to-end coupled pile sections. Further driving drives the pair of piles into the ground without any appreciable separation at the pile joint, the disc 120 accommodating whatever separation tends to take place and also shock loads which would normally be present if a concrete-to-concrete interface was present, such an interface tending to increase the risk of shattering due to direct impact loading. Pile driving continues by adding subsequent pile sections to the top of the pile until the desired length of pile is achieved.

In the modification shown in Figure 4 a metal socket 113 is formed on the upper end of the reinforcing rod 112. The socket may be attached to the rod in the manner illustrated and described with reference to Figure 2 but any suitable socket formation on the rod is appropriate. The socket has an internal thread whereby a high density plastics liner 115 can be threadably mounted within the socket. In this modification the spigot 114 formed at the lower end of the pile section has saw-tooth serrations 117, the outer diameter of which are greater than the internal diameter of the insert 115 so that when one pile section is placed on top of another with the spigot 114 in the socket 115 the pile driving operation will drive the spigot 114 into the socket and the serrations 117, on mating with the plastics liner 115, will form a permanent interference fit.

In a further modified pile section of rectangular cross-section, with a view to avoiding the corners of the pile section breaking off during the driving operation as a result of impact loads, the upper and lower ends of the pile are provided during manufacture with a steel end sleeve 20, which may have a flanged upper end as shown in Figure 5.

As the pile driver can never be certain, during a pile driving sequence, that one pile section is completely aligned with the other pile section, impact loads from the top section to the bottom section are often not transmitted over the entire facing faces of the pile sections but, if one section is at a slight angle to the other, impact loading is experienced on a corner of the pile. In view of the relative fragility of concrete under compression this often leads to fracture of the corner, the fracture extending progressively across the pile top. By eliminating corner contact as is possible with the Figure 5 modification, this problem may be mitigated.

The problem may be further mitigated by arranging to cast into at least an upper portion of the pile section, as it is being formed, reinforcing fibres which may be crinkled metal strands, glass fibres or plastics material fibres, for example, polypropylene. Reinforcing rings or helixes may be cast around the reinforcing bar(s).

Figure 6 shows the joint between two adjacent pile sections 10 each having end sleeves 20 as described with reference to Figure 5. Each pile section has a spigot and socket joint of the type shown in Figures 1 and 2 or Figures 3 and 4, but for clarity, the spigot and socket joint has not been shown in Figure 6. There is shown, however, a collapsible disc 22 between the pile sections. This disc is manufactured from an expanded metal mesh, for example EXPAMET (Registered Trade Mark). Meshes of this nature are formed by cutting slots in a metal sheet and deforming the sheet in areas of the slots by pressing certain portions thereof transversely of the plane of the sheet to form an expanded metal mesh having a thickness greater than the sheet from which it is formed. A sheet of

this mesh having outside dimensions substantially equal to the outside dimensions of the end of the pile section is cut, a circular central hole being provided for passage of the spigot 14, (114) therethrough.

It will be realised that on compressing, the sheet 22 can take up certain sock loadings. Additionally, if one pile is driven at an angle slightly different from the other pile then one section of the sheet can compress more than the other sections to accommodate this angular deviation. In a pile driving operation the sheet 22, if subjected to repeated pile driving blows, will eventually reach a flattened condition where it is effectively a solid metal disc and its shock loading capabilities will be reduced or eliminated.

To avoid this problem and to incorporate a hydraulic buffer effect into the joint the interstices of the mesh are filled with an epoxy resin having sufficient viscosity to prevent them flowing out thereof even under shock loading. It will be realised therefore that before the resin sets effectively a plurality of hydraulic pockets are provided in the disc to give a shock absorbing effect, the epoxy resin in these pockets after the pile has been driven setting to provide a rigid interconnection between the pile sections which are, of course, adhered together by the epoxy resin.

The hydraulic cushioning effect can be increased by introducing an inert filler into the epoxy resin, conveniently the filler may be sand.

Prior to placing a sheet between the ends of pile sections it is preferable that these are primed by a suitable priming agent, for example more, unfilled epoxy resin.

Clearly the use of epoxy resin is most advantageous as this material has already been used, especially in the Figures 1 and 2 embodiment, to complete the spigot and socket joint.

CLAIMS

1. A pile section comprising a concrete member including at least one reinforcing means extending generally co-incident with or parallel to the longitudinal axis of the concrete member and provided with interconnecting means at each end adapted to locate and connect with corresponding interconnecting means provided at the ends of a reinforcing means of a similar pile section whereby when similar pile sections arranged in end-to-end relationship the interconnecting means resist movement of one section away from its neighbour.

2. A pile section as claimed in claim 1, in which the reinforcing means comprises a steel bar.

3. A pile section as claimed in claim 1, in which the reinforcing means comprises a plurality of substantially parallel steel bars.

4. A pile section as claimed in any one of claims 1 to 3, in which the interconnection means comprises a socket fixed to the steel bar at the upper end of the pile section and a spigot formed by or fixed to the end of the reinforcing bar projecting beyond the base of the pile section.

5. A pile section as claimed in claim 4, in which the spigot enters the socket with some clearance and the clearance is taken up by an epoxy resin which, on setting, bonds the spigot to the socket.

6. A pile section as claimed in claim 5, in which at least one of the facing faces of the spigot and socket are roughened to enhance the adhesion of the epoxy resin.

7. A pile section as claimed in any one of the preceding claims, in which the or each reinforcing member is a standard reinforcing bar provided along its entire length with protrusions which are arranged in a helical formation.

8. A pile section as claimed in any one of claims 4 to 7, in which the socket is formed at the upper end of the reinforcing bar by a tubular member which forms a socket and which has its lower end deformed to firmly embrace the upper end of the reinforcing bar such that it is clamped on to the end of the reinforcing bar.

9. A pile section as claimed in claim 8, in which the length of the socket and the deformed end are each so chosen that with a spigot held in the socket by epoxy resin the tensile force required to separate the spigot from the socket and the tubular member forming the socket from the top of the reinforcing bar is greater than the tensile strength of the reinforcing bar.

10. A pile section as claimed in any one of claims 4 to 7, in which the socket is manufactured from a relatively rigid plastics material.

11. A pile section as claimed in any one of claims 4 to 7 and 10, in which the spigot is manufactured from a relatively rigid plastics material.

12. A pile section as claimed in claim 10 or claim 11, in which at least one of the spigot and socket have surfaces which provide an interference fit.

13. A pile section as claimed in claim 12, in which the surfaces are serrated.

14. A pile section as claimed in claim 8, in which the socket is lined by a rigid plastics material lining which is positively located in the socket by, for example, threaded means.

15. A pile section as claimed in claim 14, in which the end of the steel bar is serrated, the serrations having a saw-tooth form with the inclined faces of the saw teeth being inclined in the direction of insertion of the spigot into the lining.

16. A pile section as claimed in claim 1, in which the interconnection means comprises a socket formed at each end of the bar and a short interconnecting bar having or forming spigots at each end adapted for insertion in adjacent sockets of neighbouring bars to provide the interconnection.

17. A pile section as claimed in claim 1, in which the interconnection means comprises a corresponding externally and internally threaded member at the ends of the reinforcing bar.

18. A pile section as claimed in claim 17, in which the threads are multistart threads having a large pitch.

19. A pile section as claimed in claim 17, in which the threads have interrupted pitches whereby rigid interconnection of the sections is

achieved with the minimum of rotation therebetween.

20. A pile section as claimed in any one of the preceding claims, in which at one end thereof there is provided a disc of a reticular material which is at least partially collapsible as a result of force applied to the joint on pile driving and which has in its interstices a fluent hardenable filler.

21. A pile section as claimed in claim 20, in which the filler is an epoxy resin.

22. A pile section as claimed in claim 21, in which the resin includes an inert filler.

23. A pile section as claimed in claim 22, in which the filler is sand.

24. A joint between pile sections in a sectional pile including a disc of a reticular material which is at least partially collapsible as a result of force applied to the joint on pile driving and which has in its interstices a fluent hardenable filler.

25. A joint as claimed in claim 24, in which the filler is an epoxy resin.

26. A joint as claimed in claim 25, in which the resin includes an inert filler.

27. A joint as claimed in claim 26, in which the filler is sand.

28. A pile section substantially as hereinbefore described with reference to Figures 1 and 2 or Figure 3 or Figure 4 or Figures 5 and 6 of the accompanying drawings.

29. A joint between pile sections in a sectional pile substantially as hereinbefore described with reference to Figures 5 and 6 of the accompanying drawings.

30. Any novel subject matter or combination including novel subject matter herein disclosed, whether or not within the scope of or relating to the same invention as any of the preceding claims.

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